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Egg Loss From Pacific Herring Spawns in Barkley Sound in 1988

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ABSTRACT

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Herring spawn was sampled throughout the incubation period in Barkley Sound, British Columbia, at 38 stations on 8 transects extending from the inshore to the offshore limits of egg deposition. Egg predators were identified and enumerated. About 22,000 birds (chiefly gulls and diving ducks), 26 million invertebrates (starfish and snails), and 8 gray whales consumed the eggs from an estimated 271, 1021, and 235 tonnes of herring, respectively. This predation accounted for about 20% of the eggs deposited in the study area. Spawn measurements (sample weight and eggs on vegetation) and observations (% cover of vegetation, plant height, egg layers on vegetation, and eggs on bottom substrate), varied considerably, making it difficult to determine where and how eggs were lost, or to substantiate the egg loss attributed to predators.

RÉSUMÉ

Haegele, C. W. et J. F. Schweigert. 1989. Perte d'oeufs lors de la fraie du hareng du Pacifique dans le détroit de Barkley en 1988. Can. MS Rep. Fish. Aquat. Sci. 2037: 37 p.

Les oeufs de hareng ont été échantillonnés tout au cours de la période d'incubation dans le détroit de Barkley en Colombie-Britannique, à 38 stations le long de huit transects tracés entre la limite vers le rivage et la limite au large de la zone de dépôt des oeufs. Les prédateurs d'oeufs ont été déterminés et dénombrés. Environ 22 000 oiseaux (principalement des mouettes et des canards plongeurs), 26 millions d'invertébrés (étoiles de mer et escargots) ainsi que 8 baleines grises se nourrissaient des oeufs à raison de 271, 1021 et 235 tonnes d'oeufs de hareng, respectivement. Cette prédation correspond à environ 20 % des oeufs déposés dans la région étudiée. Les mesures du frai (poids d'échantillons et oeufs sur la végétation) ainsi que les observations (% couverture de la végétation, hauteur des plantes, couches d'oeufs sur la végétation, et oeufs sur le fond), ont considérablement varié; c'est pourquoi il était difficile de déterminer quand et de quelle façon les oeufs étaient perdus ou encore de confirmer que la perte d'oeufs était véritablement attribuable aux prédateurs.

INTRODUCTION

Herring egg loss from spawning grounds in British Columbia is of concern primarily because stock assessments utilize spawn survey data to estimate spawner biomass. Spawning ground surveys, especially those conducted by SCUBA divers, collect data on vegetation type, density, and height and on the number of egg layers on vegetation and bottom substrate. Egg density is then calculated from these observations and used together with information on spawning bed size and patchiness of egg deposition to estimate egg numbers and consequently spawner biomass (Schweigert and Fournier 1982; Schweigert et al. 1985). If egg loss prior to these spawn surveys is sufficient to alter visual observations, then this would result in underestimates of spawner biomass. In addition, egg loss resulting in egg death reduces the number of larvae produced, which may affect recruitment and hence, ultimately, stock size.

There have been several studies of egg loss from Pacific herring spawns but there is no consensus on its magnitude. Apparently, the two major causes of egg loss are predation and physical translocation through wave action. Munro and Clemens (1931) observed, inventoried, and sampled birds on herring spawning grounds over several years. They concluded that, near Nanaimo on the east coast of Vancouver Island, 12,000 ducks consumed the spawn from 36 tonnes of herring and that an undetermined number of eggs were eaten by 40,000 gulls. Outram (1958) found that 56-99% of eggs on intertidal eelgrass (*Zostera marina*) in Barkley Sound, on the west coast of Vancouver Island, were lost during incubation. Egg loss from bird predation amounted to 30-55%, the remaining loss was due to wave action. Vermeer (1981) estimated that 75,000 surf scoters (*Melanitta perspicillata*) occurred along the west and east coast of Vancouver Island during two weeks in March, 1978, when they consumed the eggs from 1030 tonnes of herring. The herring spawning stock biomass for the west and east coast of Vancouver Island in 1978 was estimated at 75,000 tonnes (Haist et al. 1987); consequently surf scoters would have removed about 1.4% of the eggs. Palsson (1984) reported egg losses of 95-99% from very light density spawns in Puget Sound. Bird predation was the major cause of loss, followed by snail and gammarid predation. Two studies on the east coast of Vancouver Island examined egg loss from wave action. Hart and Tester (1934) estimated that 40% of eggs in one spawn were washed ashore and that 70% of these eggs died. Hay and Miller (1982) found that 26% of eggs in a spawn were cast ashore in windrows. Both studies noted that adjacent spawns did not appear to experience this magnitude of egg loss.

Egg loss may be determined in two ways. Spawn can be sampled throughout the incubation period to determine if there is a decrease in egg density. Alternately, sources of egg loss can be identified and estimated. In this study, both approaches were used. A relatively large geographical area was selected for the study so that results would have general applicability. Spawn was sampled at 8 locations, 4 of which were on the Vancouver Island shoreline and 4 on smaller islands in northern Barkley Sound (Fig. 1). Standard visual observations of the type used to estimate egg density from SCUBA surveys of herring spawn (Schweigert and Fournier 1982) were made and spawn was sampled for egg density estimates. Predators were identified and enumerated. An attempt was made to determine rations for avian predators. Egg loss from wave action was not estimated separately since no

substantial windrows of eggs were encountered and washed-up spawn appeared to be the major food item of non-diving avian predators.

METHODS

Transects on historical herring spawning beds in northern Barkley Sound were identified using gillnet leadline, which was oriented perpendicular to the shore and deployed before spawning. About 5 stations were equidistantly spaced along transects over the depth range usually utilized by herring for spawning. Thus, stations were 10-40 m apart, depending on the slope of the beach. Sampling sites were marked at these stations with 5 m long pennants attached to and perpendicular to the transect leadline. Pennants were flagged at 1 m intervals with surveyor's tape. Sample plots were 0.5 m^2 quadrats, a square with 0.7 m sides. One side of the quadrat was laid along the pennant with one corner at the meter mark and the other side extending away from the transect line. The quadrat was then flipped once shorewardly. This was done to make quadrat placement non-selective.

Transects were sampled on alternate days over 12 days. On the first sampling day, visual observations were made at all sample sites and the rooted or attached vegetation in the quadrat at the first sample site at each station, and the adhering eggs, removed for further analysis. On the second sampling day, visual observations were made at the remaining sample sites and the second site at each station was harvested. This was repeated up to the last sampling day. Visual observations made were % cover of vegetation (the proportion of the quadrat covered by vegetation), vegetation type (App. table 1), plant height, egg layers on vegetation and on bottom substrate, and depth. Invertebrates that were observed eating eggs were enumerated. Observed depth was corrected to chart datum.

Harvested vegetation and eggs were separated by vegetation type into fractions, which were weighed, and weighed subsamples preserved in Gilson's fluid. The preserved samples were processed by immersion in alcoholic (25% by volume) 1N KOH at 40° C for approximately 1 hr to liberate the eggs. (This solution dissolves the glue by which herring eggs are attached.) Eggs were preserved in 10% formalin for approximately 1 week. The preservative was vacuum extracted, the eggs weighed, and two aliquots of approximately 200 to 400 eggs removed, weighed and the eggs counted. The number of eggs on each vegetation type was then calculated and eggs·m^2 was twice the sum of these estimates. Each sample was assigned to a dominant vegetation type (App. table 1) based on which type had the most eggs attached. Eggs on bottom substrate were estimated from egg layer observations [1 layer = 340,000 eggs·m^{-2} (Haegele et al. 1979)].

Birds were surveyed from a boat, using binoculars. Two types of vessels were used for these observations; the CSS VECTOR and 6 m work boats. Surveys from the CSS VECTOR were limited to open water because of vessel size, whereas surveys from the workboats were conducted close to shore. Birds were identified to species, where possible, and grouped into categories of abundance and behaviour for data presentation (App. table 2). Specimens of

species observed to be feeding on herring spawn were obtained by shooting. Formalin was injected immediately into the alimentary tract through the mouth. The birds were weighed and the alimentary tract dissected, weighed, and preserved in 10% formalin. The preserved gut was weighed and the contents identified and weighed. The weight of the contents was adjusted to fresh weight by the ratio of fresh gut weight to preserved gut weight.

When required, egg weights were converted to egg numbers using an individual egg weight of $2.38 \cdot 10^{-3}$ g (Hay and Miller 1982). Egg numbers were converted to spawners using a relative fecundity of $1.0 \cdot 10^{8}$ eggs$\cdot$tonne^{-1} (Hay 1985).

RESULTS

SPAWN SAMPLES

There were between 3 and 8 stations per transect. Stations on the Vancouver Island shore (transect 1-4) were never deeper than 4 m below chart datum, whereas those on the smaller islands (transect 6-9) were as deep as 10 m below chart datum (Fig. 2). Some of the transects were not sampled early in the incubation period because of strong winds (Table 1). There were 253 quadrat observations and 122 harvested samples (App. table 3). Sea grasses or filamentous algae were the dominant vegetation type in 97% of samples. Samples with sea grasses as the dominant vegetation type differed significantly from those where filamentous algae dominated (Table 2). Sea grasses samples had higher mean percent cover, plant height, sample weight, and eggs on vegetation. Filamentous algae samples had higher mean egg layers and eggs on bottom.

Observations and measurements were regressed on incubation time for all samples and for samples grouped by the two major vegetation types (Table 3). The slope was negative, r was low, and P was high for most regressions. Hence, these regressions probably indicate trends, but the parameters are not well determined. Percent cover and plant height actually increased with incubation time for sea grasses samples, while they decreased slightly for filamentous algae samples. Egg layers decreased with incubation time at a rate of about 0.1 layer per day. Sample weight decreased with incubation time and at a greater rate for filamentous algae samples than for sea grasses samples. Eggs on bottom showed no trend with time for sea grasses samples (Fig. 3), but decreased for filamentous algae samples (Fig. 4). Eggs on vegetation appear to decrease substantially with time for both sea grasses ($P = 0.09$) and filamentous algae ($P = 0.12$) samples (Fig. 5 and 6). However, some very high egg densities (above $2 \cdot 10^{6}$ eggs$\cdot$m^{2}) in early samples had a large influence on the regressions. If the 10 samples (8% of total samples) with egg densities above $2 \cdot 10^{6}$ eggs$\cdot$m^{-2} are deleted, then the regressions are:

$E_{sg} = 729.39 - 1.91D$ ($n = 42$, $r = 0.04$, $P = 0.67$) and

$E_{fi} = 195.42 + 7.74D$ ($n = 67$, $r = 0.06$, $P = 0.64$), where

E_{sg} = $(eggs \cdot 10^{-3}) \cdot m^{-2}$ for sea grasses samples,
E_{fi} = $(eggs \cdot 10^{-3}) \cdot m^{-2}$ for filamentous algae samples, and
D = incubation day.

Although the parameters are estimated less well in these regressions than in the regressions using all samples, there is no longer a detectable trend in egg density with incubation time.

PREDATION

Avian predators

Bird abundance increased from 7742 on March 15, 5 days prior to spawning, to 11,214 on March 21, the midpoint of the spawning period, and to 21,627 on March 29, 6 days after the end of spawning (App. table 4 and Fig. 7). The March 21 and 27 estimates do not include the Toquart sector and hence may be low by ≈2000 birds, the average for this sector. On April 7, when the first wave spawn had hatched and a second wave spawn was observed in the Toquart sector, 30,555 birds were counted. Gulls showed the largest increase, from 4113 on March 15 to 14,808 on March 27, after which time they slowly declined. Scoters increased from 1771 on March 15 to 5661 on March 27, after which time they stabilized until April 7, when they increased to 12,143 on April 7. These additional ≈6000 birds apparently moved into the study area from Sechart Channel, 10 km east of the Toquart sector, where they had been observed feeding on spawn deposited March 17-20. Diving ducks increased from ≈500 at the start of spawning to ≈1000 by March 29. The diving ducks were always seen nearshore and the low diving duck estimates for March 15 and 22 were on days when the survey was made from the CSS VECTOR, which could not operate near shore. Other diving birds were mostly grebes and cormorants. Grebes frequently moved out of the study area and never numbered more than ≈1600 animals, which were only seen early in the study. Cormorants numbered ≈400 during spawning and ≈100 before and after spawning. Non-diving birds were mostly bald eagles, Canada geese, and crows. Maximum eagle number was 109 at the start of spawning. Canada geese increased from 12 to ≈100 birds. Crows were not always seen: they were present only during lower tides, when they fed intertidally. The maximum estimate was 175 birds.

Gulls, diving ducks, crows, and Canada geese were observed eating spawn. Stomach samples showed gulls, scoters, and 3 species of diving ducks sampled (Barrow's goldeneye, bufflehead, and harlequin) eating spawn, while cormorants were feeding exclusively on herring (App. table 5). Some gulls also took herring. It was estimated, using maximum observed gut content and maximum bird estimates, that birds consumed 24,458 kg of spawn (Table 4). An alternate estimate, using maximum bird estimates and the regression Log F = -0.293 + 0.85(Log W) (Nilsson and Nilsson 1976), where F = daily food consumption and W = bird weight, is that birds consumed 64,600 kg of herring spawn (Table 5). These estimates are equivalent to the spawn from 102.9 and 271.5 tonnes of herring, respectively.

Invertebrate predators

Only two invertebrates, leather stars (*Dermasterias imbricata*) and turban snails (*Astrea gibberosa*), were commonly observed eating herring spawn. Their abundance was estimated in 40 quadrats on 7 transects during sampling on the fifth to tenth incubation day. It was calculated from occurrence and density estimates, and area of spawn, that 16.4 million turban snails and 9.4 million leather stars were present (Table 6). Using estimates of daily egg consumption from laboratory experiments (unpublished data), these invertebrates would have consumed 102 billion eggs over the 14 day incubation period, which is equivalent to the eggs from 1020.6 tonnes of herring (Table 6).

Mammalian predators

Of the 4 species of sea mammals observed (App. table 4), only gray whales were observed to feed on herring spawn. There was a maximum of 8 gray whales in the study area. If each is assumed to consume herring spawn equivalent to 2% of its body weight daily during the 14 day incubation period, then, at an average body weight of 25 tonnes, they consumed 56 tonnes of herring spawn, which is equivalent to the eggs from 235 tonnes of herring. The maximum number of sea lions estimated was 358 and the maximum number of harbour seals was 27 (App. table 4). Neither was observed eating spawn.

DISCUSSION

It was estimated from SCUBA surveys that 7842 tonnes of herring spawned in the study area (Haist and Schweigert 1989). We calculated that birds removed the eggs from 271 tonnes, gray whales the eggs from 235 tonnes, and invertebrates the eggs from 1021 tonnes, a total of 1527 tonnes, resulting in a 19.5% egg loss (Table 8). These predation estimates are for maximum egg loss, since maximum predator counts were used on the assumption that not all predators of any one species were seen on any individual survey. Actually, birds probably increased during the incubation period and the maximum was not achieved until midway through the incubation period. The same was true for gray whales, the maximum number was not observed until later in the incubation period. Predation by gray whales was localized and sites grazed by them were probably not sampled for spawn in this study. The estimate of predation by invertebrates can be assumed to be reasonable, if sampling was adequate to estimate abundance. Because of their apparent ubiquitousness, they appear to be the major spawn predator. Palsson (1984) noted that invertebrates had the capacity to consume most of the herring eggs in the low density spawns in Quartermaster Harbor.

The estimated 19.5% egg loss over a 14 day incubation period is probably insufficient to be detected at the level of sampling in this study, given the large variability in observations and measurements. The corollary

is that observations from which egg density is predicted for stock assessments (vegetation type, percent cover, egg layers on vegetation and bottom substrate) can be made throughout the incubation period, without producing serious bias in spawner biomass estimates. Percent cover could be expected to decrease from initial values if plants were removed by predators or wave action. Plant height would decrease if the tops of plants were broken off by wave action or cropped by predators. Egg layers would decrease if eggs were removed from plants which remained in place and intact. Eggs on bottom would decrease from predation by grazers. All of these undoubtedly occurred, but at relatively innocuous levels.

Our estimate of egg loss disagrees with those made by Palsson (1984) and Outram (1958), both of whom estimated up to 99% egg loss. However, Palsson sampled only low density spawns and Outram intertidal spawns. Other studies were restricted to estimating eggs removed by storms in individual spawns (Hart and Tester 1984, Hay and Miller 1982) and their estimates were for 40% and 26% egg loss, respectively. Our estimate of egg loss from bird predation is similar to those made by Munro and Clemens (1931), who concluded that ducks did not appreciably contribute to a reduction in herring stocks.

Egg loss in herring spawns may be restricted to certain locations and depth strata. Our sampling effort was insufficient to stratify samples for analysis by location (transect) or by depth and vegetation type. To obtain precise estimates of where and to what degree such egg loss occurs, future studies of egg loss in Pacific herring spawns would require increased sampling effort.

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Table 1. Observed weather and day of incubation, by date, when transects were sampled in Barkley Sound in 1988.

Date	Wind direction and speed (nmph)	Incubation day for transect 1	2	3	4	6	7	8	9
Ma 20	calm								
Ma 21	calm								
Ma 22	SE 30-35								2
Ma 23	SE 30-35								
Ma 24	SE 5-10								
Ma 25	SE 20-30						5	4	
Ma 26	SE 5-10	3	4	5		2			6
Ma 27	NW 20-30				7		7	6	
Ma 28	SE 20-30	5	6	7					8
Ma 29	W 5-10				9	5	9	8	
Ma 30	calm	7	8	9					10
Ma 31	calm				11		11	10	
Ap 01	calm	9	10	11					12

Table 2. Comparison (independent 2 sample t-test) of observations and measurements by dominant vegetation type of sample.

Data type	Sea grasses N	Sea grasses Mean	Sea grasses SD	Filamentous algae N	Filamentous algae Mean	Filamentous algae SD	T	DF	P
Percent cover	110	68.2	23.5	134	24.6	23.5	14.4	233	0.00
Plant height (cm)	110	46.4	22.1	134	9.0	7.4	17.0	129	0.00
Egg layers	110	1.7	1.5	134	2.7	1.9	-4.2	241	0.00
Sample weight (g)	47	2820.8	2111.0	72	1358.5	1979.3	3.8	94	0.00
Eggs on bottom[a,b]	58	108.8	118.6	94	194.1	155.6	-3.8	143	0.00
Eggs on vegetation[b]	47	971.3	889.4	72	442.7	809.3	3.3	91	0.00

[a]Samples with no eggs on bottom were deleted.
[b]In 1000s of eggs per m^2.

Table 3. Linear regression ($y = a + bx$) of observations and measurements (y) by day of incubation (x) for all samples and samples grouped by dominant vegetation type.

Veg. type	y	N	a	b	r	P
All	Percent cover	253	36.66	1.19	0.10	0.13
	Height (cm)	253	22.26	0.58	0.06	0.34
	Layer	253	2.98	-0.11	0.15	0.02
	Weight (g)	122	2508.11	-81.78	0.11	0.24
	Eggs on bottom[a,b]	161	192.37	-4.04	0.07	0.39
	Eggs on vegetation[b]	122	1054.96	-57.28	0.19	0.42
Sea grasses	Percent cover	110	54.41	2.18	0.23	0.02
	Height (cm)	110	35.15	1.78	0.20	0.04
	Layer	110	2.17	-0.07	0.11	0.24
	Weight (g)	47	3432.71	-83.36	0.11	0.46
	Eggs on bottom[a,b]	58	110.72	-0.31	0.01	0.96
	Eggs on vegetation[b]	47	1548.66	-78.66	0.25	0.09
Fil. algae	Percent cover	134	25.08	-0.07	0.01	0.93
	Height (cm)	134	9.32	-0.06	0.02	0.83
	Layer	134	3.47	-0.13	0.17	0.05
	Weight (g)	72	2104.83	-106.20	0.15	0.21
	Eggs on bottom[a,b]	94	272.24	-12.24	0.20	0.06
	Eggs on vegetation[b]	72	817.20	-53.29	0.19	0.12

[a]Samples with no eggs on bottom were deleted.
[b]In 1000s of eggs per m^2.

Table 4. Direct estimate of herring spawn consumed by birds in Barkley Sound over a 14 day incubation period (March 20 to April 5, 1988). The daily ration is the maximum observed value for food as percent of body weight for birds with herring spawn in the gut (Table 4).

Bird type	Max. no. estimated	Av body wt. (g)	Daily ration (% of body wt.)	Spawn eaten (kg) Daily	Spawn eaten (kg) Total	Equivalent spawners (mt)
Gulls	14808	1203	8.71	1552	21722	91.3
Scoters	5661	1126	2.16	138	1928	8.1
Ducks	1419	932	1.39	18	257	1.1
Crows[a]	175	900	5.00	8	110	0.5
Canada geese[a]	126	5000	5.00	32	441	1.9
Total				1748	24458	102.9

[a]Body weight and ration estimated for crows and Canada geese.

Table 5. Indirect estimate of herring spawn consumed by birds in Barkley Sound over a 14 day incubation period (March 20 to April 5, 1988). Daily ration is the mean of daily food consumption estimated with Log F = -0.293 + 0.85(Log W), where F = daily food consumption and W = weight of birds sampled (Nilsson and Nilsson 1976).

Bird type	Max. no. estimated	Daily ration (g) (95% C.I.)	Spawn eaten (kg) Daily	Spawn eaten (kg) Total	Equivalent spawners (mt)
Gulls	14808	211 (196 to 226)	3124	43743	183.8
Scoters	5661	200 (192 to 208)	1132	15851	66.6
Ducks	1419	169 (135 to 203)	240	3357	14.1
Crows[a]	175	165	29	404	1.7
Canada geese[a]	126	709	89	1251	5.3
Total			4614	64600	271.5

[a]Ration for crows and Canada geese determined from estimated body weight.

Table 6. Estimates of invertebrate predators (in millions) [based on occurrence (proportion of quadrats with predator), density (no. per square m) when occurring, and area of spawn (330.6 ha)] and their potential herring egg consumption (billions) over a 14 day incubation period. Daily egg consumption (ration) was estimated from laboratory experiments (unpublished data).

Species	Occur-rence	Density (95% C.I.)	Number	Ration	Eggs eaten	Equivalent spawners (mt)
Leather star	0.375	7.6 (4.1-11.1)	9.4	600	79.15	791.5
Turban snail	0.500	9.9 (7.0-12.8)	16.4	100	22.91	229.1
Total			25.8		102.06	1020.6

Table 7. Estimate of herring spawn consumed by gray whales over a 14 day incubation period. Daily ration was estimated as 2% of body weight (P. F. Olesiuk, pers. comm.).

Number	Body weight (mt)	Ration (kg)	Spawn eaten (kg)	Equivalent spawners (mt)
8	25	500	56000	235.3

Table 8. Summary of herring spawn consumed by predators. The total spawner biomass in the study area was estimated at 7842 mt from an independent survey (Haist and Schweigert 1989).

Predators	Spawn eaten [equivalent spawners (mt)]	% of total spawning stock
Birds	271.5	3.5
Invertebrates	1020.6	13.0
Mammals	235.3	3.0
Total	1527.4	19.5

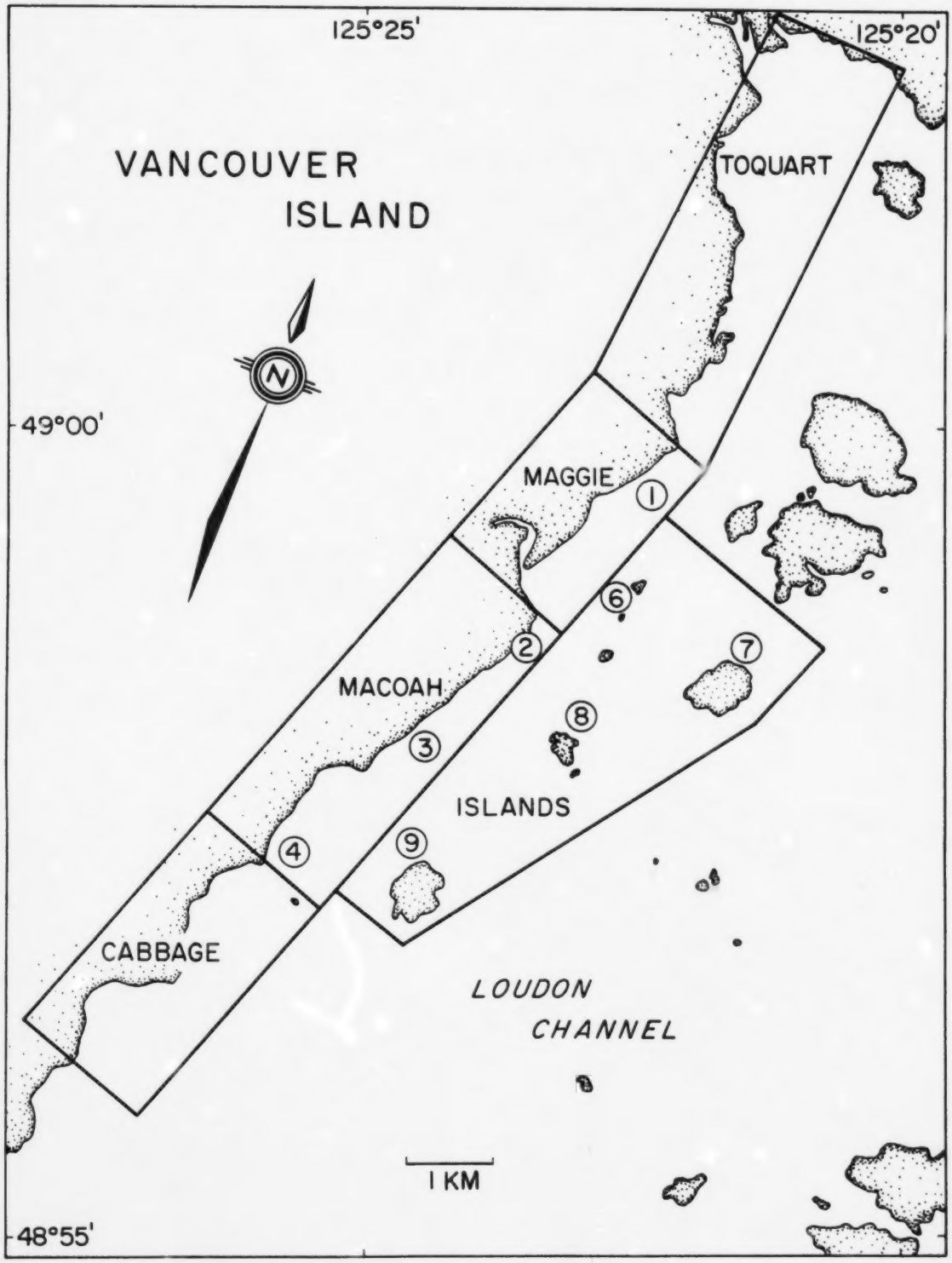

Fig. 1. Location of Barkley Sound herring egg loss study. Circles show transect locations and named boxes delineate bird count sectors.

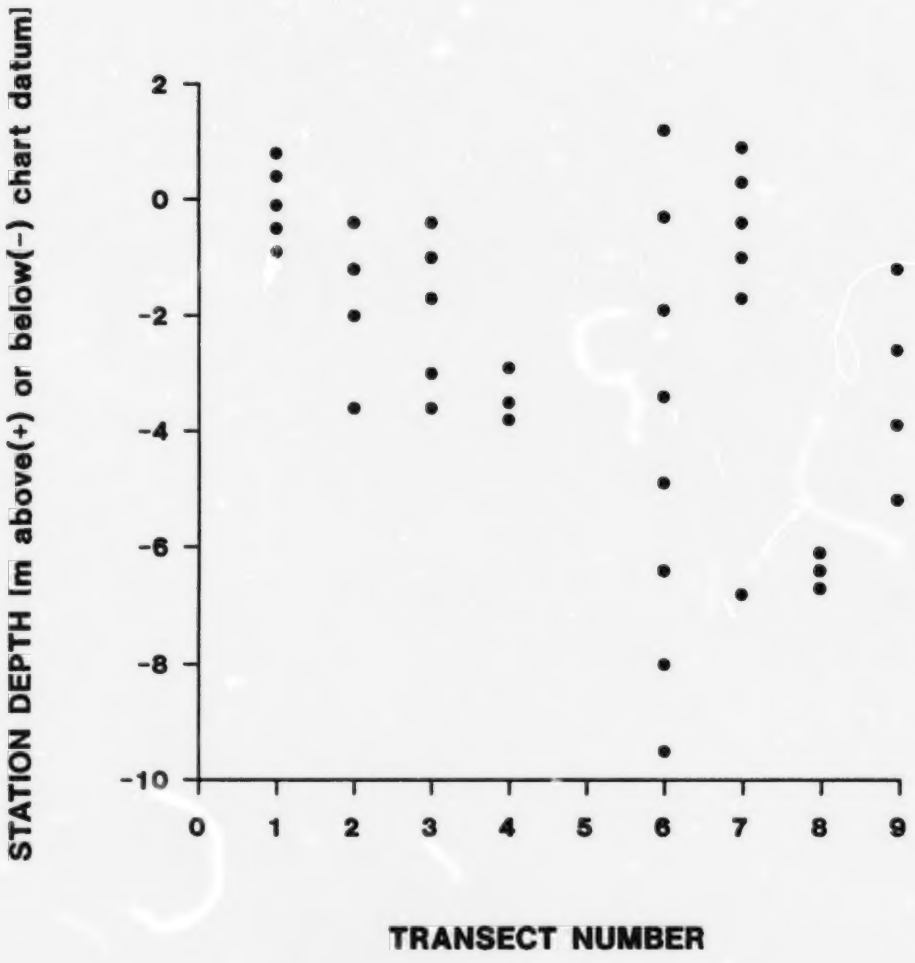

Fig. 2. Depth of stations, by transect, at which herring spawn samples were obtained.

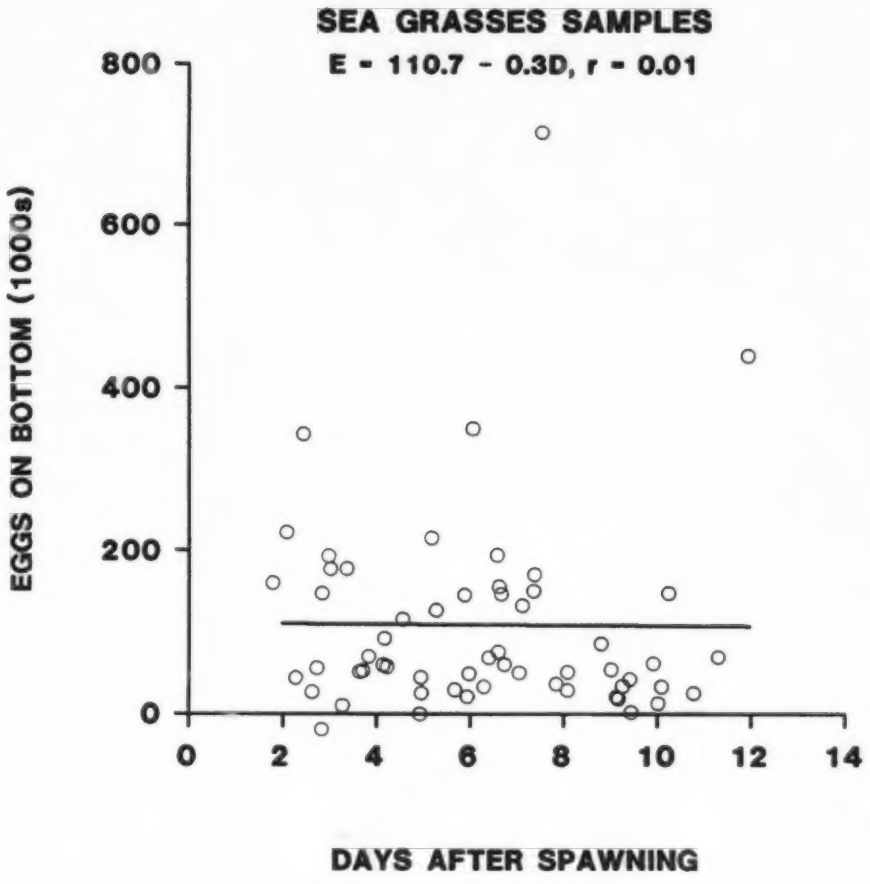

Fig. 3. Relationship between herring eggs · m^{-2} on bottom substrate and incubation day for samples where sea grasses dominated.

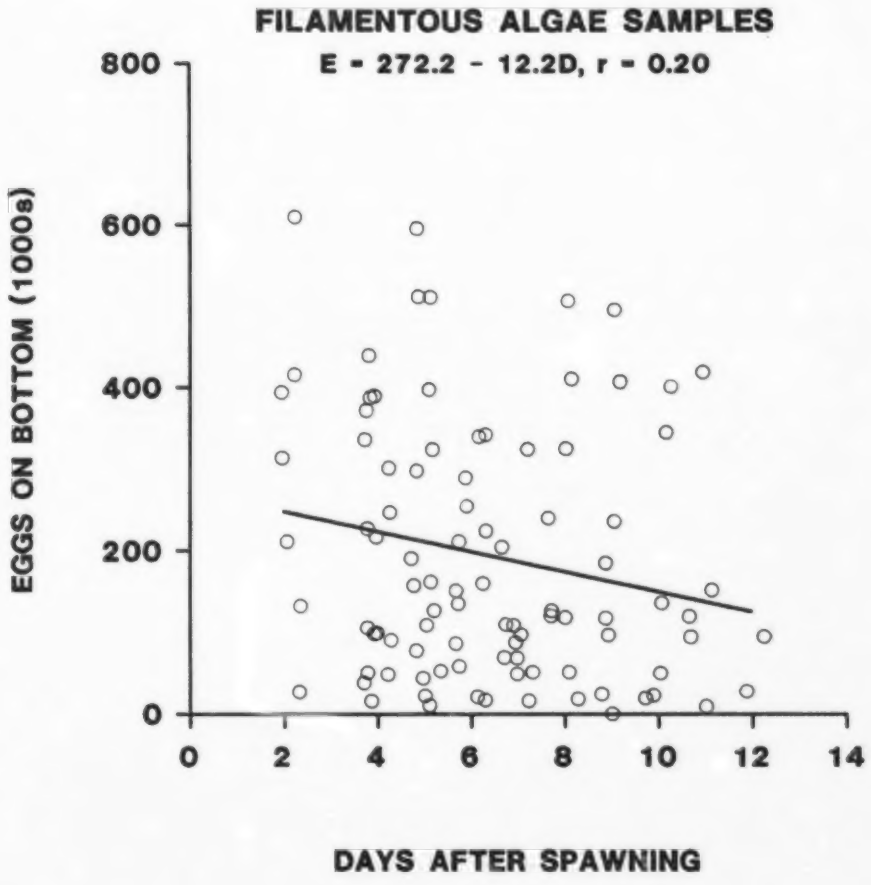

Fig. 4. Relationship between herring eggs · m^{-2} on bottom substrate and incubation day for samples where filamentous algae dominated.

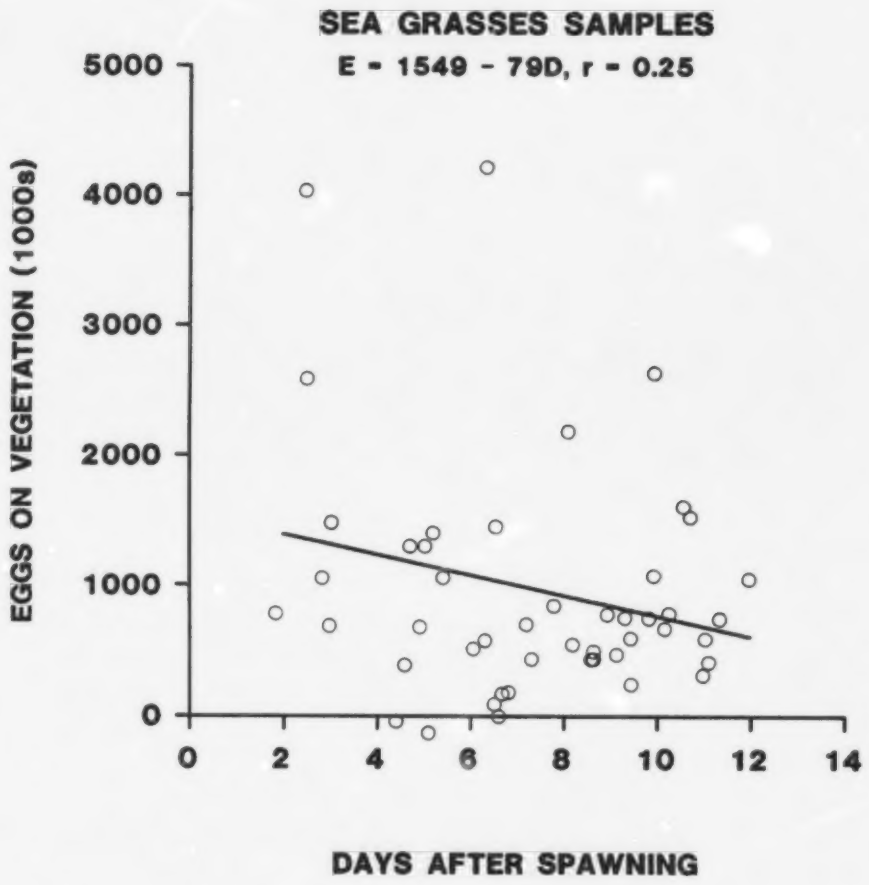

Fig. 5. Relationship between herring eggs · m^{-2} on vegetation and incubation day for samples where sea grasses dominated.

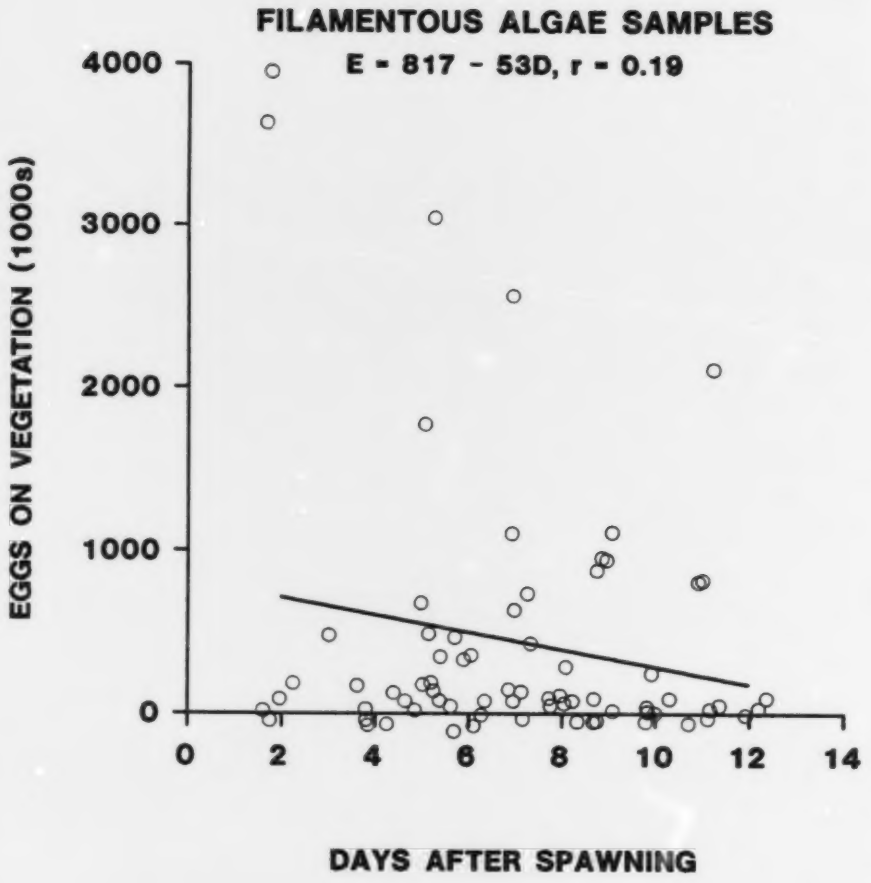

Fig. 6. Relationship between herring eggs . m^{-2} on vegetation and incubation day for samples where filamentous algae dominated.

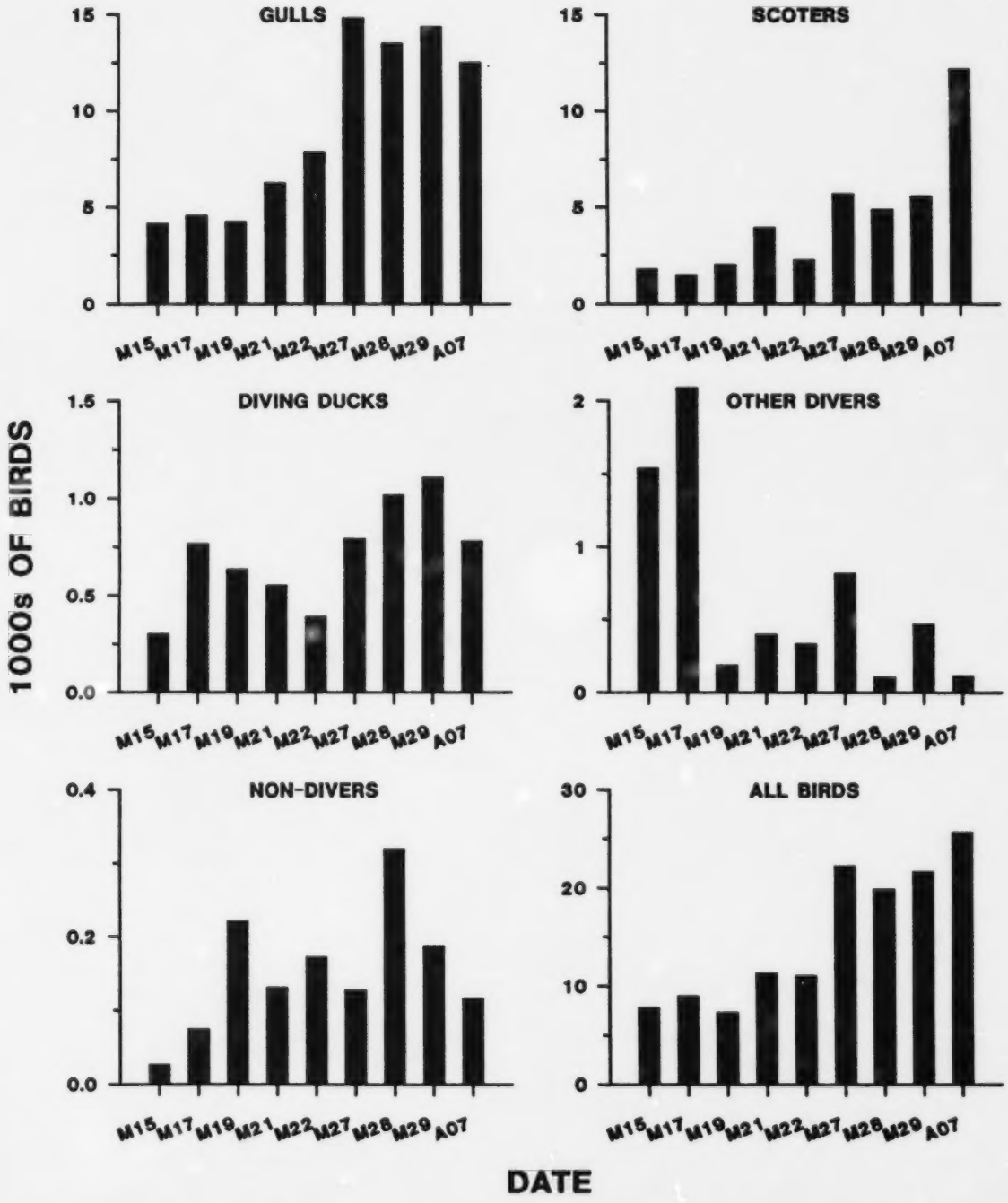

Fig. 7. Abundance of birds on or near herring spawning grounds in Barkley Sound in 1988 (breakdown by species is given in Appendix table 4).

Appendix tables

Appendix table 1. Vegetation types and the most common species of marine vegetation encountered.

Type	Species
Sea grasses	*Zostera marina* *Phyllospadix scouleri*
Rockweed	*Fucus distichus*
Kelps	*Agarum sp.* *Laminaria sp.*
Japanese weed	*Sargassum muticum*
Foliose algae	*Gigartina sp.* *Iridea sp.* *Prionitis sp.* *Rhodymenia sp.*
Filamentous algae	*Agardhiella sp.* *Ceramium sp.* *Corallina sp.* *Gelidium sp.* *Gracilaria sp.* *Rhodomela sp.*

Appendix table 2. Birds and sea mammals identified and counted in Barkley Sound in 1988. Common and scientific names are given and species are grouped by categories used in the data analysis.

Gulls	
Gull	*Larus sp.*
Scoters	
Black scoter	*Melannita nigra*
Surf scoter	*Melanitta perspicillata*
White-winged scoter	*Melanitta deglandi*
Scoter	*Melanitta sp.*
Other diving ducks	
Bufflehead	*Bucephala albeola*
Barrow's goldeneye	*Bucephala islandica*
Common goldeneye	*Bucephala clangula*
Goldeneye	*Bucephala sp.*
Harlequin	*Histrionicus histrionicus*
Oldsquaw	*Clangula hyemalis*
Pintail	*Anas acuta*
Common merganser	*Mergus merganser*
Red-breasted merganser	*Mergus serrator*
Merganser	*Mergus sp.*
Greater scaup	*Aythya marila*
Other diving birds	
Horned grebe	*Podiceps auritus*
Red-necked grebe	*Podiceps grisegena*
Western grebe	*Aechmophorus occidentalis*
Grebe	*Podiceps sp.* or *Aechmophorus sp.*
Brandt's cormorant	*Phalacrocorax penicillatus*
Double-crested cormorant	*Phalacrocorax auritus*
Pelagic cormorant	*Phalacrocorax pelagicus*
Cormorant	*Phalacrocorax sp.*
Common loon	*Gavia immer*
Pacific loon	*Gavia artica*
Common murre	*Uria aalge*
Pigeon guillemot	*Cepphus columba*
Non-diving birds	
Crow	*Corvus caurinus* or *Corvus brachyrhynchos*
Black oystercatcher	*Haematopus bachmani*
Black turnstone	*Arcnaria melanocephala*
Canada goose	*Branta canadensis*
Brant	*Branta bernicla* or *Branta nigricans*
Bald eagle	*Haliaeetus leucocephalus*
Great blue heron	*Ardea herodias*
Sea mammals	
Stellar sea lion	*Eumetopias jubatus*
California sea lion	*Zalophus californianus*
Harbour seal	*Phoca vitulina*
Gray whale	*Eschrichtius robustsus*

Appendix table 3. Observations and measurements for quadrats sampled for herring spawn in Barkley Sound in 1988.

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m^2) on veg.	Eggs (1000s/m^2) on btm.
1	3	-0.9	seagr	35	90	3.0	3206.0	1430.9	170.0
1	3	-0.9	seagr	35	60	3.0	-	-	170.0
1	3	-0.9	seagr	35	90	2.0	-	-	170.0
1	3	-0.9	seagr	35	50	2.0	-	-	170.0
1	3	-0.5	seagr	30	60	0.8	1310.0	527.4	0.0
1	3	-0.5	seagr	30	70	1.5	-	-	0.0
1	3	-0.5	seagr	30	25	0.5	-	-	42.5
1	3	-0.5	seagr	30	60	1.0	-	-	34.0
1	3	-0.1	seagr	20	60	2.0	2836.0	1213.9	34.0
1	3	-0.1	seagr	20	100	2.0	-	-	3.4
1	3	-0.1	seagr	20	100	2.0	-	-	0.0
1	3	-0.1	seagr	20	60	2.0	-	-	0.0
1	3	0.4	filam	10	10	4.0	1116.0	446.3	0.0
1	3	0.4	filam	10	10	4.0	-	-	0.0
1	3	0.4	filam	10	2	2.0	-	-	0.0
1	3	0.4	filam	10	2	2.0	-	-	0.0
1	5	-0.9	seagr	20	80	2.0	2212.0	1004.5	0.0
1	5	-0.9	seagr	20	75	2.0	-	-	0.0
1	5	-0.9	seagr	20	60	1.0	-	-	0.0
1	5	-0.5	seagr	20	50	0.7	1350.0	498.5	0.0
1	5	-0.5	seagr	20	30	0.3	-	-	0.0
1	5	-0.5	seagr	20	75	1.5	-	-	0.0
1	5	-0.1	seagr	20	80	2.0	2948.0	1147.5	0.0
1	5	-0.1	seagr	20	100	3.0	-	-	0.0
1	5	-0.1	filam	45	45	3.0	-	-	0.0
1	5	0.4	filam	12	20	6.0	1574.0	574.9	17.0
1	5	0.4	filam	12	5	3.0	-	-	0.0
1	5	0.4	filam	12	2	3.0	-	-	0.0
1	5	0.8	filam	10	5	3.0	-	-	0.0
1	5	0.8	filam	10	30	4.0	-	-	0.0
1	7	-0.9	seagr	30	80	0.5	1678.0	602.6	170.0
1	7	-0.9	seagr	30	75	0.5	-	-	170.0
1	7	-0.5	seagr	20	60	0.8	904.0	341.6	136.0
1	7	-0.5	seagr	20	70	1.5	-	-	153.0
1	7	-0.1	seagr	20	90	2.5	2904.0	1284.5	170.0
1	7	-0.1	seagr	20	70	3.0	-	-	51.0
1	7	0.4	filam	8	20	5.0	792.0	251.2	0.0
1	7	0.4	filam	8	2	3.0	-	-	0.0
1	7	0.8	filam	10	10	2.5	970.0	394.9	0.0
1	7	0.8	filam	10	50	5.0	-	-	51.0
1	9	-0.9	seagr	30	50	1.3	1324.0	593.2	0.0
1	9	-0.5	seagr	30	60	2.0	940.0	422.9	85.0
1	9	-0.1	seagr	20	65	6.0	1420.0	613.6	17.0
1	9	0.4	filam	15	5	3.0	76.0	19.9	0.0

Appendix table 3 (cont'd)

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m^2) on veg.	Eggs (1000s/m^2) on btm.
1	9	0.8	filam	20	65	8.0	2034.0	779.6	136.0
2	4	-3.6	filam	8	10	2.0	132.0	41.1	85.0
2	4	-3.6	filam	8	10	2.0	-	-	51.0
2	4	-3.6	filam	8	10	2.0	-	-	34.0
2	4	-2.0	seagr	40	20	0.8	600.0	95.3	68.0
2	4	-2.0	filam	14	60	3.0	-	-	68.0
2	4	-2.0	seagr	40	90	2.0	-	-	34.0
2	4	-2.0	seagr	30	60	2.5	-	-	68.0
2	4	-1.2	filam	20	25	1.0	318.0	30.0	0.0
2	4	-1.2	seagr	90	40	0.5	-	-	102.0
2	4	-1.2	seagr	90	60	0.8	-	-	68.0
2	4	-1.2	seagr	90	80	0.8	-	-	68.0
2	4	-0.4	filam	10	30	0.5	808.0	61.4	34.0
2	4	-0.4	filam	10	10	0.5	-	-	0.0
2	4	-0.4	filam	10	15	0.5	-	-	0.0
2	4	-0.4	seagr	40	50	1.0	-	-	0.0
2	6	-3.6	filam	10	10	3.0	340.0	75.6	68.0
2	6	-3.6	filam	10	10	2.0	-	-	17.0
2	6	-2.0	filam	15	70	2.0	1674.0	420.6	51.0
2	6	-2.0	seagr	30	80	3.0	-	-	51.0
2	6	-2.0	seagr	30	65	1.0	-	-	68.0
2	6	-1.2	seagr	90	80	0.3	2316.0	519.1	17.0
2	6	-1.2	seagr	90	60	0.3	-	-	34.0
2	6	-1.2	seagr	90	80	0.5	-	-	51.0
2	6	-0.4	filam	20	15	0.5	392.0	16.8	0.0
2	6	-0.4	seagr	40	65	0.5	-	-	0.0
2	8	-3.6	filam	10	10	2.0	220.0	38.2	68.0
2	8	-3.6	filam	10	5	2.0	-	-	34.0
2	8	-2.0	seagr	25	60	2.0	2816.0	835.4	34.0
2	8	-2.0	seagr	25	75	3.5	-	-	17.0
2	8	-1.2	seagr	70	70	0.5	2196.0	537.0	0.0
2	8	-1.2	seagr	70	60	1.0	-	-	75.0
2	8	-0.4	filam	20	25	0.1	394.0	63.4	0.0
2	8	-0.4	seagr	50	70	0.5	-	-	0.0
2	10	-3.6	filam	5	5	2.0	24.0	5.7	51.0
2	10	-2.0	seagr	30	70	2.5	2430.0	732.1	34.0
2	10	-1.2	seagr	80	55	1.0	2052.0	617.9	68.0
2	10	-0.4	seagr	40	80	1.0	2496.0	725.5	0.0
3	5	-3.6	filam	7	50	2.0	1654.0	482.3	595.0
3	5	-3.6	filam	7	30	2.0	-	-	510.0
3	5	-3.6	filam	7	25	2.0	-	-	510.0
3	5	-3.6	filam	7	50	2.0	-	-	306.0
3	5	-3.0	filam	3	10	0.5	118.0	9.3	17.0
3	5	-3.0	filam	3	5	2.0	-	-	0.0
3	5	-3.0	filam	7	5	1.5	-	-	170.0

Appendix table 3 (cont'd)

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m^2) on veg.	Eggs (1000s/m^2) on btm.
3	5	-3.0	filam	7	10	1.0	-	-	204.0
3	5	-1.7	seagr	50	100	2.0	4020.0	1469.5	238.0
3	5	-1.7	filam	5	25	1.5	-	-	170.0
3	5	-1.7	seagr	50	95	1.0	-	-	136.0
3	5	-1.7	seagr	70	100	1.0	-	-	102.0
3	5	-1.0	filam	5	65	1.0	958.0	83.9	0.0
3	5	-1.0	seagr	70	90	0.5	-	-	0.0
3	5	-1.0	seagr	50	70	0.5	-	-	0.0
3	5	-1.0	seagr	80	70	0.5	-	-	0.0
3	7	-3.6	filam	5	25	2.0	624.0	169.7	127.5
3	7	-3.6	filam	10	25	2.0	-	-	51.0
3	7	-3.6	filam	10	40	2.0	-	-	85.0
3	7	-3.0	filam	3	5	0.0	-	-	0.0
3	7	-3.0	filam	7	10	1.5	-	-	17.0
3	7	-3.0	filam	10	15	2.0	-	-	51.0
3	7	-1.7	seagr	50	15	1.0	738.0	113.1	136.0
3	7	-1.7	filam	25	60	1.5	-	-	102.0
3	7	-1.7	seagr	70	70	0.5	-	-	51.0
3	7	-1.0	filam	70	10	0.1	348.0	9.4	0.0
3	7	-1.0	seagr	50	75	2.0	-	-	85.0
3	7	-1.0	seagr	70	75	0.5	-	-	0.0
3	7	-0.4	seagr	50	60	1.5	2260.0	274.7	0.0
3	7	-0.4	seagr	80	60	0.3	-	-	0.0
3	7	-0.4	seagr	80	60	0.3	-	-	0.0
3	9	-3.6	filam	8	10	2.5	642.0	165.8	170.0
3	9	-3.6	filam	8	10	2.5	-	-	255.0
3	9	-3.0	filam	8	2	2.0	160.0	21.4	17.0
3	9	-3.0	filam	8	15	2.0	-	-	102.0
3	9	-1.7	seagr	60	100	0.2	2590.0	587.0	51.0
3	9	-1.7	seagr	70	100	0.4	-	-	51.0
3	9	-1.0	seagr	50	100	0.3	1570.0	235.1	27.2
3	9	-1.0	seagr	80	100	0.2	-	-	0.0
3	9	-0.4	seagr	70	100	0.3	3824.0	747.6	0.0
3	9	-0.4	seagr	100	100	0.7	-	-	0.0
3	11	-3.6	filam	6	15	2.0	316.0	36.1	170.0
3	11	-3.0	filam	7	5	2.0	240.0	45.1	136.0
3	11	-1.7	seagr	70	70	1.0	2764.0	748.1	51.0
3	11	-1.0	seagr	80	85	0.8	1952.0	325.9	0.0
3	11	-0.4	seagr	100	100	0.7	2332.0	449.6	0.0
4	7	-3.8	filam	12	80	2.5	6740.0	2543.9	306.0
4	7	-3.5	filam	13	40	2.0	2026.0	740.6	54.4
4	7	-2.9	filam	8	60	2.0	1920.0	644.2	0.0
4	9	-3.8	filam	10	50	3.0	3366.0	1136.2	17.0
4	9	-3.5	filam	12	70	4.0	2514.0	869.1	0.0
4	9	-2.9	filam	6	60	2.0	1358.0	123.4	0.0

Appendix table 3 (cont'd)

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m²) on veg.	Eggs (1000s/m²) on btm.
4	11	-3.8	filam	10	30	3.0	2610.0	915.0	0.0
4	11	-3.5	filam	12	40	3.0	2080.0	836.3	102.0
4	11	-2.9	filam	3	40	2.0	496.0	127.2	6.8
6	2	-9.5	folio	15	15	1.0	-	-	34.0
6	2	-8.0	jweed	70	20	4.5	-	-	68.0
6	2	-6.4	jweed	70	20	4.5	2962.0	1088.1	76.5
6	2	-6.4	filam	7	10	10.0	-	-	34.0
6	2	-4.9	seagr	50	15	4.0	1692.0	646.0	34.0
6	2	-4.9	seagr	50	5	0.5	-	-	0.0
6	2	-3.4	filam	5	10	8.0	462.0	108.0	153.0
6	2	-3.4	seagr	30	15	4.0	-	-	212.5
6	2	-1.9	filam	5	10	8.0	246.0	75.3	595.0
6	2	-1.9	filam	5	10	3.0	-	-	408.0
6	2	-0.3	filam	10	100	4.0	8128.0	3547.2	0.0
6	2	-0.3	filam	20	55	1.0	-	-	204.0
6	2	1.2	filam	10	80	6.0	9528.0	3909.1	306.0
6	2	1.2	filam	10	80	8.0	-	-	408.0
6	5	-9.5	folio	15	5	1.5	112.0	22.1	68.0
6	5	-6.4	filam	7	10	5.0	352.0	116.6	51.0
6	5	-4.9	seagr	70	5	0.1	126.0	36.9	0.0
6	5	-3.4	filam	15	25	5.0	484.0	163.6	408.0
6	5	-1.9	filam	5	10	3.0	372.0	117.6	127.5
6	5	-0.3	filam	15	70	0.5	1134.0	462.4	85.0
6	5	1.2	filam	15	75	8.0	8224.0	2960.4	51.0
7	5	-6.8	filam	5	10	4.0	364.0	93.3	0.0
7	5	-6.8	filam	3	2	2.5	-	-	0.0
7	5	-6.8	filam	3	5	3.0	-	-	0.0
7	5	-1.7	seagr	60	60	8.0	3872.0	1446.2	34.0
7	5	-1.7	seagr	60	90	8.0	-	-	0.0
7	5	-1.7	seagr	60	50	5.0	-	-	17.0
7	5	-1.7	seagr	60	50	5.0	-	-	34.0
7	5	-1.0	seagr	50	90	2.0	-	-	0.0
7	5	-1.0	seagr	50	50	2.0	-	-	0.0
7	5	-0.4	seagr	30	80	1.0	1794.0	724.4	0.0
7	5	-0.4	seagr	30	80	1.0	-	-	0.0
7	5	-0.4	seagr	30	90	1.0	-	-	0.0
7	5	-0.4	seagr	30	100	2.0	-	-	0.0
7	5	0.3	filam	10	40	8.0	4274.0	1730.4	306.0
7	5	0.3	filam	10	50	6.0	-	-	102.0
7	5	0.3	rockw	15	75	6.0	-	-	510.0
7	5	0.3	rockw	8	72	8.0	-	-	408.0
7	7	-6.8	filam	4	2	3.0	112.0	28.7	0.0
7	7	-6.8	filam	4	2	2.0	-	-	0.0
7	7	-6.8	filam	4	2	3.0	-	-	0.0
7	7	-1.7	seagr	50	100	1.0	2920.0	858.2	0.0

Appendix table 3 (cont'd)

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m^2) on veg.	Eggs (1000s/m^2) on btm.
7	7	-1.7	seagr	50	100	2.0	-	-	0.0
7	7	-1.7	seagr	60	50	2.0	-	-	0.0
7	7	-1.0	seagr	50	90	2.0	-	-	0.0
7	7	-1.0	seagr	50	50	2.0	-	-	0.0
7	7	-0.4	seagr	30	80	0.5	1462.0	232.0	0.0
7	7	-0.4	seagr	30	90	0.2	-	-	0.0
7	7	-0.4	seagr	30	100	0.5	-	-	0.0
7	7	0.3	filam	10	50	6.0	2830.0	1184.6	102.0
7	7	0.3	filam	10	50	6.0	-	-	204.0
7	7	0.3	rockw	20	55	2.5	-	-	204.0
7	9	-6.8	filam	5	10	2.0	-	-	0.0
7	9	-1.7	seagr	50	50	3.0	1904.0	582.7	34.0
7	9	-1.7	seagr	50	35	3.0	-	-	34.0
7	9	-1.0	seagr	50	50	3.0	-	-	0.0
7	9	-0.4	seagr	40	50	1.5	902.0	297.8	0.0
7	9	-0.4	seagr	40	65	1.5	-	-	0.0
7	9	0.3	filam	10	90	6.0	3220.0	980.9	425.0
7	9	0.3	filam	10	75	5.0	-	-	510.0
7	9	0.9	rockw	15	75	6.0	1620.0	408.9	510.0
7	9	0.9	rockw	20	35	3.0	-	-	476.0
7	11	-6.8	filam	5	5	2.0	132.0	28.1	0.0
7	11	-1.7	seagr	70	80	2.5	3720.0	1460.9	34.0
7	11	-1.0	seagr	40	70	1.5	4390.0	1669.6	0.0
7	11	-0.4	seagr	30	90	0.3	1798.0	569.8	0.0
7	11	0.3	filam	8	72	8.0	5788.0	2111.8	408.0
8	4	-6.7	filam	3	5	2.5	250.0	63.6	459.0
8	4	-6.7	filam	7	30	2.5	-	-	408.0
8	4	-6.7	filam	7	10	2.5	-	-	382.5
8	4	-6.7	filam	7	10	2.5	-	-	204.0
8	4	-6.4	filam	5	5	2.0	626.0	114.1	238.0
8	4	-6.4	filam	5	20	3.0	-	-	306.0
8	4	-6.4	filam	5	50	3.0	-	-	357.0
8	4	-6.4	filam	5	50	3.0	-	-	357.0
8	4	-6.1	filam	5	2	0.5	70.0	2.8	102.0
8	4	-6.1	filam	5	5	2.0	-	-	102.0
8	4	-6.1	filam	5	10	2.0	-	-	238.0
8	4	-6.1	filam	5	2	2.0	-	-	102.0
8	6	-6.7	filam	7	20	2.0	1218.0	315.5	340.0
8	6	-6.7	filam	7	15	2.0	-	-	340.0
8	6	-6.7	filam	7	10	2.0	-	-	306.0
8	6	-6.4	filam	7	20	2.0	1048.0	290.3	255.0
8	6	-6.4	filam	7	50	2.0	-	-	204.0
8	6	-6.4	filam	7	50	2.0	-	-	204.0
8	6	-6.1	filam	7	10	2.0	292.0	40.1	136.0
8	6	-6.1	filam	5	2	2.0	-	-	170.0

Appendix table 3 (cont'd)

Tran. no.	Incu. Day	Depth (m)	Veg. type	Percent cover	Height (cm)	Egg layers	Weight (g)	Eggs (1000s/m^2) on veg.	Eggs (1000s/m^2) on btm.
8	6	-6.1	filam	7	10	2.0	-	-	170.0
8	8	-6.7	filam	6	5	2.5	800.0	176.8	510.0
8	8	-6.7	filam	6	2	2.5	-	-	425.0
8	8	-6.4	filam	10	30	2.5	1704.0	366.7	255.0
8	8	-6.4	filam	10	30	2.5	-	-	306.0
8	8	-6.1	filam	5	2	1.5	354.0	46.1	102.0
8	8	-6.1	filam	5	2	1.0	-	-	102.0
8	10	-6.7	filam	3	5	2.5	414.0	59.7	408.0
8	10	-6.4	filam	4	30	2.5	1446.0	348.5	340.0
8	10	-6.1	filam	7	2	0.7	96.0	6.7	153.0
9	2	-5.2	filam	5	15	0.5	242.0	13.0	0.0
9	2	-3.9	seagr	25	75	4.0	9088.0	4091.8	340.0
9	2	-2.6	filam	5	25	1.0	384.0	15.4	0.0
9	2	-1.2	seagr	80	10	3.0	6432.0	2762.2	170.0
9	6	-5.2	filam	5	10	0.8	500.0	15.0	0.0
9	6	-3.9	seagr	40	60	3.0	10960.0	4087.6	340.0
9	6	-2.6	filam	5	20	0.1	366.0	5.0	34.0
9	6	-1.2	seagr	40	25	3.0	1580.0	508.7	136.0
9	8	-5.2	filam	3	5	0.5	110.0	5.3	142.8
9	8	-3.9	seagr	35	60	5.0	4918.0	2114.8	714.0
9	8	-2.6	filam	5	25	0.2	370.0	24.0	0.0
9	10	-5.2	filam	8	20	1.5	236.0	13.1	34.0
9	10	-3.9	seagr	40	80	2.5	7724.0	2562.1	170.0
9	10	-2.6	filam	8	40	0.5	1012.0	39.2	30.6
9	10	-1.2	seagr	40	60	1.0	3670.0	1194.9	51.0
9	12	-5.2	filam	2	5	1.0	280.0	9.3	17.0
9	12	-3.9	seagr	22	40	4.5	3639.0	1108.2	425.0
9	12	-2.6	filam	10	25	0.7	580.0	27.1	0.0
9	12	-1.2	filam	6	12	2.0	730.0	78.2	102.0

Appendix table 4. Number of birds and sea mammals observed on or near herring spawning grounds in Barkley Sound in 1988.

Species	March								April
	15	17	19	21	22	27	28	29	7
Gulls									
Gull sp.	4113	4516	4226	6236	7834	14808	13479	14330	12492
Scoters									
Black scoter	0	0	0	1	0	0	0	0	30
Surf scoter	1768	1459	1854	3874	2203	5540	3054	5542	11831
W.-winged scoter	3	0	150	25	8	35	38	0	132
Scoter sp.	0	0	0	0	0	86	1750	0	150
Other diving ducks									
Bufflehead	31	213	251	115	0	185	32	47	193
Barrow's goldeneye	79	0	91	103	0	297	193	0	75
Common goldeneye	64	511	233	118	0	68	80	0	56
Goldeneye sp.	0	0	0	98	350	121	618	910	170
Harlequin	9	5	19	109	0	95	67	120	123
Oldsquaw	0	2	4	0	0	6	0	0	7
Pintail	0	0	12	0	0	0	0	0	18
Common merganser	83	29	12	1	35	6	20	26	0
R.-b. merganser	3	2	11	0	0	10	2	0	15
Merganser sp.	28	0	0	0	0	0	0	0	0
Greater scaup	0	0	0	6	0	0	0	0	120
Other diving birds									
Horned grebe	4	137	26	2	1	7	2	0	2
Red-necked grebe	36	0	1	1	0	2	0	0	0
Western grebe	1306	1570	1	25	0	665	50	409	5
Grebe sp.	42	0	0	0	0	0	0	0	0
Brandt's cormorant	2	0	0	265	152	84	0	0	43
D.-c. cormorant	10	46	5	0	44	1	0	9	3
Pelagic cormorant	100	329	146	54	130	43	8	46	50
Cormorant sp.	0	0	0	47	0	8	40	0	0
Common loon	1	1	1	0	1	4	0	1	3
Pacific loon	32	0	0	0	0	0	0	0	0
Common murre	1	0	0	0	0	1	0	0	0
Pigeon guillemot	1	0	4	1	1	0	0	0	5
Non-diving birds									
Crow sp.	0	12	92	0	0	0	175	49	0
B. oystercatcher	0	0	1	0	0	0	5	0	0
Black turnstone	0	0	30	0	0	0	0	8	0
Canada goose	12	17	63	21	126	109	100	115	100
Brant	0	0	0	0	0	0	0	0	1
Bald eagle	13	45	34	109	46	18	39	14	15
Great blue heron	1	0	1	0	0	0	0	1	0
Sea mammals									
Stellar sea lion	22	17	12	23	0	12	44	26	1
Cal. sea lion	157	122	88	161	8	142	314	180	13
Harbour seal	3	11	27	11	0	11	17	19	1
Gray whale	1	1	0	1	0	7	4	8	6

Appendix table 5. Fresh wet weight of bird (FWB) and gut (FWG), preserved wet weight of gut (PWG) and food in gut (PWF), food weight adjusted to fresh weight (FWF), food as percent of body weight (PER), and major prey-item and its state of digestion for birds harvested in Barkley Sound in 1988. All weights are in grams.

Species	Date	FWB	FWG	PWG	PWF	FWF	PER	Prey	State
Cal. gull	24.03.88	1380	114	127	1.3	1.2	0.09	spawn	fresh
G.-w. gull	24.03.88	1610	180	201	14.0	12.5	0.79	fish	partly
G.-w. gull	24.03.88	1490	158	171	14.8	13.7	0.93	spawn	fresh
G.-w. gull	24.03.88	1536	166	181	32.1	29.4	1.95	spawn	partly
G.-w. gull	24.03.88	1588	248	247	77.7	78.0	5.17	spawn	fresh
G.-w. gull	30.03.88	1147	166	173	31.7	30.4	2.72	spawn	fresh
G.-w. gull	30.03.88	1115	148	162	36.5	33.3	3.08	spawn	fresh
G.-w. gull	30.03.88	1252	209	239	67.4	58.9	4.94	spawn	fresh
G.-w. gull	30.03.88	1044	200	231	80.0	69.3	7.11	spawn	fresh
Herring gull	24.03.88	1080	121	132	16.2	14.9	1.39	fish	partly
Herring gull	24.03.88	1221	137	154	28.9	25.7	2.15	spawn	fresh
Herring gull	30.03.88	1122	122	135	17.5	15.8	1.43	spawn	fresh
Herring gull	30.03.88	1144	126	134	24.0	22.6	2.01	spawn	fresh
Mew gull	24.03.88	720	76	86	6.9	6.1	0.85	spawn	fresh
Thayer's gull	24.03.88	1184	163	182	40.3	36.1	3.14	spawn	fresh
Thayer's gull	28.03.88	1145	157	159	25.4	25.1	2.24	spawn	fresh
Thayer's gull	28.03.88	1296	232	257	115.0	103.8	8.71	spawn	fresh
Western gull	24.03.88	1344	136	158	10.2	8.8	0.66	fish	partly
Western gull	28.03.88	1043	100	113	16.3	14.4	1.40	spawn	fresh
B's cormorant	24.03.88	2889	246	276	1.9	1.7	0.06	fish	fully
B's cormorant	24.03.88	2694	239	265	33.7	30.4	1.14	fish	partly
B's cormorant	24.03.88	3160	268	290	70.0	64.7	2.09	fish	partly
B's cormorant	24.03.88	3002	383	394	99.0	96.2	3.31	fish	partly
B's cormorant	24.03.88	3198	467	482	230.5	223.3	7.51	fish	partly
Pel. cormorant	24.03.88	2682	240	255	50.5	47.5	1.80	fish	partly
Surf scoter	24.03.88	1088	127	142	4.4	3.9	0.36	spawn	partly
Surf scoter	24.03.88	1036	117	135	5.4	4.7	0.45	spawn	fully
Surf scoter	24.03.88	1048	138	160	6.4	5.5	0.53	spawn	fresh
Surf scoter	24.03.88	1274	128	142	7.8	7.0	0.55	spawn	fully
Surf scoter	24.03.88	1134	143	163	8.1	7.1	0.63	spawn	fully
Surf scoter	24.03.88	1154	135	151	8.0	7.2	0.62	spawn	fully
Surf scoter	24.03.88	1148	194	221	27.7	24.3	2.16	spawn	fresh
Surf scoter	28.03.88	1212	176	184	26.4	25.3	2.13	spawn	fresh
B.'s goldeneye	28.03.88	1312	155	172	4.1	3.7	0.28	spawn	partly
B.'s goldeneye	28.03.88	977	125	138	4.7	4.3	0.44	spawn	partly
B.'s goldeneye	28.03.88	1268	160	171	6.6	6.2	0.49	spawn	fresh
B.'s goldeneye	30.03.88	1235	138	171	2.3	1.9	0.15	spawn	fresh
Bufflehead	30.03.88	481	53	65	5.1	4.2	0.87	spawn	fresh
Harlequin	28.03.88	733	70	83	5.2	4.4	0.60	spawn	fresh
Harlequin	28.03.88	712	71	82	5.7	4.9	0.70	spawn	partly
Harlequin	28.03.88	780	83	97	12.5	10.7	1.39	spawn	fresh